ARC
10

MEASURING SET 44C Mk 1

OPERATION & MAINTENANCE

WAYNE KERR

MP MASTER
MA24491

MEASURING SET 44C Mk 1

Issue 6 : History Sheet

(Incorporates changes detailed in Addendum sheets to Issue 5, dated October 1979, September 1981 and October 1981).

Title page	Issue 6, March 1982 was Issue 5, April 1979 Reference Number TP54/6 was TP54/5. WKR Limited was Wilmot Breeden Electronics Ltd.
Page 8	Last line. TP54/6 was TP54/5.
Page 13	Fig.2a D8 type was BAX13 R60 value was 1M5.
Page 14	Fig.2b C54 value was 470p IC1 type was µA702C.
Page 37	Clause 4.6.9 OUTPUT LEVEL dBm (left) was OdB.
Page 43	R47a, R47b, R47c, R51a, R51b, R51c: were 11M 150ppm Welwyn 4036G. R56 was 3.16M 150ppm Welwyn 4936G Also, R49,R50,R53,R54,R55a,R55b,R57 and R58: were 150ppm Welwyn 4036G R59 was Erie 81/S
Page 44	R60 was 1.5M Erie 81/S R61 and R62 were Erie 81/S
Page 48	C53 tolerance was ±10% C54 was 470p ±5% 400V Suflex H.S.
Page 49	IC1 was Texas 702C D8 was Mullard BAX13 CV9637
Back cover	Wayne Kerr/WKR was Wilmot Breeden Electronics.

List of Components	R83 was 2.2k (no tolerance shown)
	R84 was 30k
	R121a was 390, Electrosil C5
	R122a and R135 added
	R132 was 1M ± 10%
	C7 was 220 (Mullard 108, no suffix)
	C46 was 2.2, 64V, Mullard C428AR/H2.5
	C55 was AIC
	C58, C60, C61 added
" " "	Detail changes, not affecting values, apply to the following: R4 - R82 inclusive, R84 - R90, R100, R101, R104 - R107, R110 - R113, R117 - R120, R122, R123 - R134. C1 - C3, C5, C6, C8 - C17, C19, C20, C26 - C33, C35 - C38, C40 - C45, C47 - C51, C56. VT13, VT15, VT25, VT26, IC1, D1 - D14, M1, JK1 - JK3, SG, SJ.

Issue 6

March 1982

MEASURING SET 44C Mk 1

to Post Office Specification RC5545D

The Wayne Kerr Reference Number of this Publication is TP54/6

WKR Limited. Durban Road Bognor Regis Sussex

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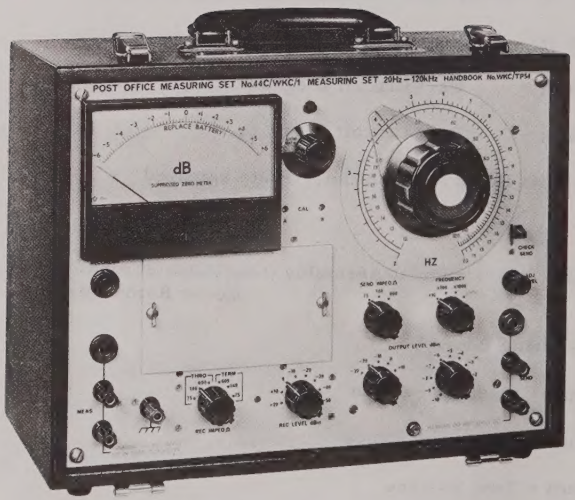

POST OFFICE MEASURING SET No.44C/WKC/1 MEASURING SET 20Hz – 120kHz HANDBOOK No.WKC/TPM
REPLACE BATTERY
dB
HZ
CAL
CHECK SEND
FREQUENCY
SEND IMPED.Ω
OUTPUT LEVEL dBm
REC IMPED.Ω
REC LEVEL dBm
MEAS

1.0 TECHNICAL SUMMARY

1.1 GENERAL DESCRIPTION

This handbook describes the Measuring Set 44C Mk I, designed to Specification RC5545D of the Post Office Telecommunications Development Department. The 44C is a battery operated portable instrument, and is intended for general audio frequency and program circuit transmission measurements. For end to end testing two sets are required, one at each terminal.

The measuring set comprises two electrically separate sections operated from a common power source; these are, the Sending Section (oscillator) and the Level Measuring Section. The two sections can be operated separately or together, the various modes of operation being selected by a control on the front panel.

The instrument is powered by two 9V dry batteries connected in series. These are contained in a separate compartment and are accessible by removing a cover on the front panel. Alternatively, the batteries may be replaced with Power Unit No. 91A.

1.2 PERFORMANCE AND ACCURACY

The following figures apply at nominal ambient temperature and supply voltage unless otherwise stated.

1.2.1 Sending Facilities

Output Waveform	Sinusoidal
Frequency Range	20Hz to 120kHz ±1% or 1Hz (whichever is greater)
Total Harmonic Content	at least 35dB below output signal level
Output Level	-40 to +10dBm in 1dB steps
Output Impedance	75, 140 or 600Ω balanced
Output Termination	Jack No. 99B and two black terminals (SEND) connected in parallel
Output Monitor	CHECK SEND and fine level (ADJ) control enable level to be held constant to within ±0.1dB.

1.2.2 Level Measuring Facilities

Frequency Response	30Hz to 120kHz ±0.2dB relative to 800Hz 20Hz to 30Hz ±0.7dB " " "
Input Level Range	-56 to +26 dBm
Total Measuring Error	30Hz to 120kHz <±0.5dB 20Hz to 30Hz <±1dB
Input Balance at 600 & 140Ω	Reading unaffected by longitudinal voltage of 10V at 50Hz or 2V at 200kHz (except most sensitive range - see full P.O. specification RC5545)
Input Impedance	75, 140 or 600Ω through or terminated
Meter Scaling	-6 to +6dB (sub divisions 0.2dB) Suppressed Mechanical Zero
Meter Scaling Error	<±0.2dB
Input Terminations	Jack No. 99B and two black terminals (MEAS) connected in parallel
Recorder Output Impedance	>5000Ω
Recorder Output Termination	Jack No. 99B

1.3 MISCELLANEOUS DATA

Dimensions	Height 292 mm (11.5 in) Width 352 mm (13.875 in) Depth 206 mm (8.125 in)
Weight	6.7 kg (14.75 lb)
Ambient Temperature Range	$0^{\circ}C$ to $+40^{\circ}C$
Power Supply	2 x No. 29 (PP9, VT9 or equivalent) dry batteries in series (alternatively Power Unit No. 91A can be used).

Spares and Loose Items

The following items are supplied:

1 Handbook Wayne Kerr Reference Number TP54/6

2.0 OPERATING INSTRUCTIONS

2.1 PRELIMINARY

Before using the instrument, first check the condition of the batteries as follows. Set the mode switch (to the right of the meter) to the CHECK BATT position and observe the indication on the meter; if the pointer lies in the REPLACE BATTERY sector, i.e. to the left of the +3 mark, the two batteries should be replaced. To do this first remove the cover plate, which is secured by two Dzus fasteners situated on the front panel of the instrument,and pull the battery removal tapes to ease the batteries from their compartment. Replace the batteries with 2 x No. 29 (PP9, VT9 or equivalent) and refit the coverplate. Confirm the condition of the new batteries before proceeding.

NOTES: It is advisable to set the mode switch to the OFF position whilst changing batteries.
If the Power Unit No. 91A is in use, setting the mode switch to the CHECK BATT position will confirm correct operation of the power unit.
The meter is of the suppressed mechanical zero type.
The set zero screw should not be adjusted except as detailed in Section 4.4.

2.2 OPERATION

To use the oscillator (SEND) section, select the OSC ONLY position of the mode switch, press the CHECK SEND key and vary the ADJ LEVEL control so that the meter indicates 0dB. Set the SEND IMPED Ω, OUTPUT LEVEL dBm and FREQUENCY controls to the required positions and connect the circuit under test to the SEND terminals or jack, as appropriate.

NOTE: On the highest frequency range, use the red scale marked 12 to 120 in conjunction with the red x1000 position of the FREQUENCY switch.

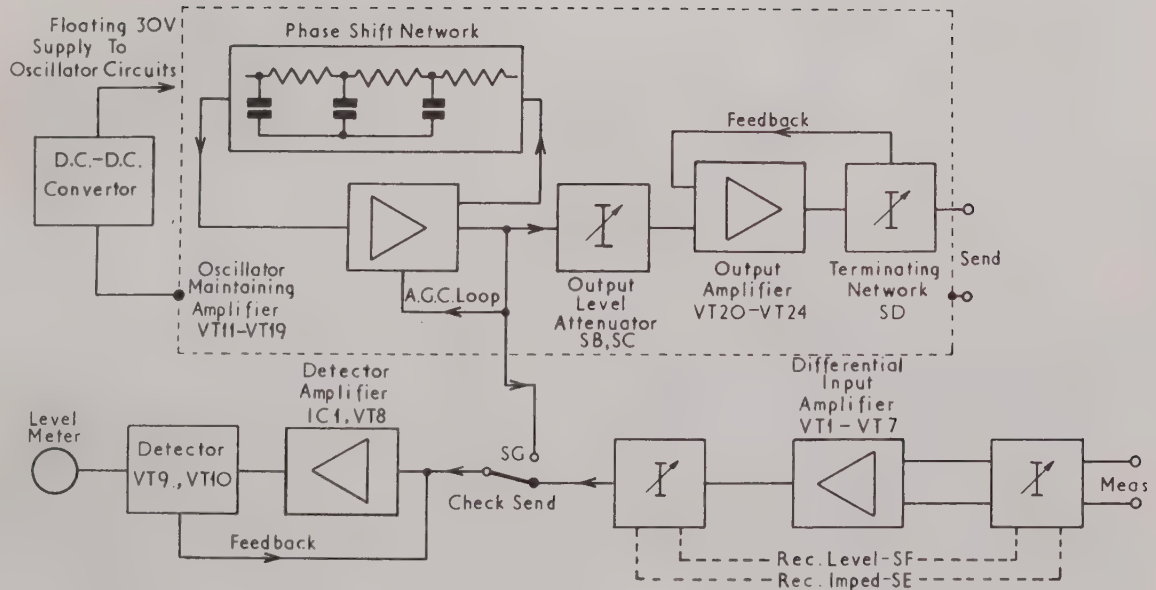


Fig.1 MS 44C Mk.1 : Block Schematic

To use the level measuring (MEAS) section, select the LMS ONLY position of the mode switch, set the REC IMPED Ω switch to the impedance of the circuit under test (using THRO or TERM as appropriate) and set the REC LEVEL dBm switch to +20.

Connect the circuit under test to the MEAS terminals or jack, as appropriate, and adjust the REC LEVEL dBm control in a clockwise direction until an on-scale meter reading is obtained. The level of the received signal is the sum of the meter reading and the REC LEVEL dBm switch setting. For example, with the REC LEVEL dBm switch set to +10 and the meter indicating -2; the level of the received signal is +10 -2 = +8dB.

When using a pen recorder, connect a decibel meter No. 19A or equivalent to the tip and ring of a plug No. 316 and insert into the RECORDER jack.

To use both the oscillator and level measuring sections at the same time, switch to ON and proceed as outlined above for the two sections. When the instrument is not in use, set the mode switch to the OFF position.

3.0 CIRCUIT DESCRIPTION

3.1 SUMMARY

The instrument comprises a sending section (oscillator), a level measuring section and a d.c. - d.c. convertor. These elements are arranged as shown in the block diagram Fig. 1. Circuits are given in Figs 2(a) and 2(b).

3.2 SENDING SECTION

3.2.1 General

The sending circuit comprises an R. C. oscillator, coupled to an amplifier via a two-stage attenuator. The low impedance amplifier output is converted to either 75Ω, 140Ω or 600Ω impedance, and is balanced. The entire sending circuit is contained within a metal box, which is electrically isolated from the instrument case. The box is connected to one of the output (SEND) terminals, the other output

terminal being connected to the output of the impedance converting circuit. The stray capacitance between the case and the box is balanced by a capacitor in parallel with a trimmer, connected between the output of the impedance converting circuit and the instrument case. By adjusting this trimmer, the capacitance between each output (SEND) terminal and the case is made equal and the output circuit is balanced. The operation of this balancing circuit depends on the fact that the supply to the oscillator is floating. This floating supply is obtained from a d.c.-d.c. convertor, which is described separately. A circuit diagram of the sending section is given in Fig. 2(a).

3.2.2 Oscillator

The oscillator is of the ladder network type and may conveniently be divided into three sections as follows: (1) the phase shift network, (2) the maintaining amplifier and (3) amplitude stabilisation circuit. Each is described separately below.

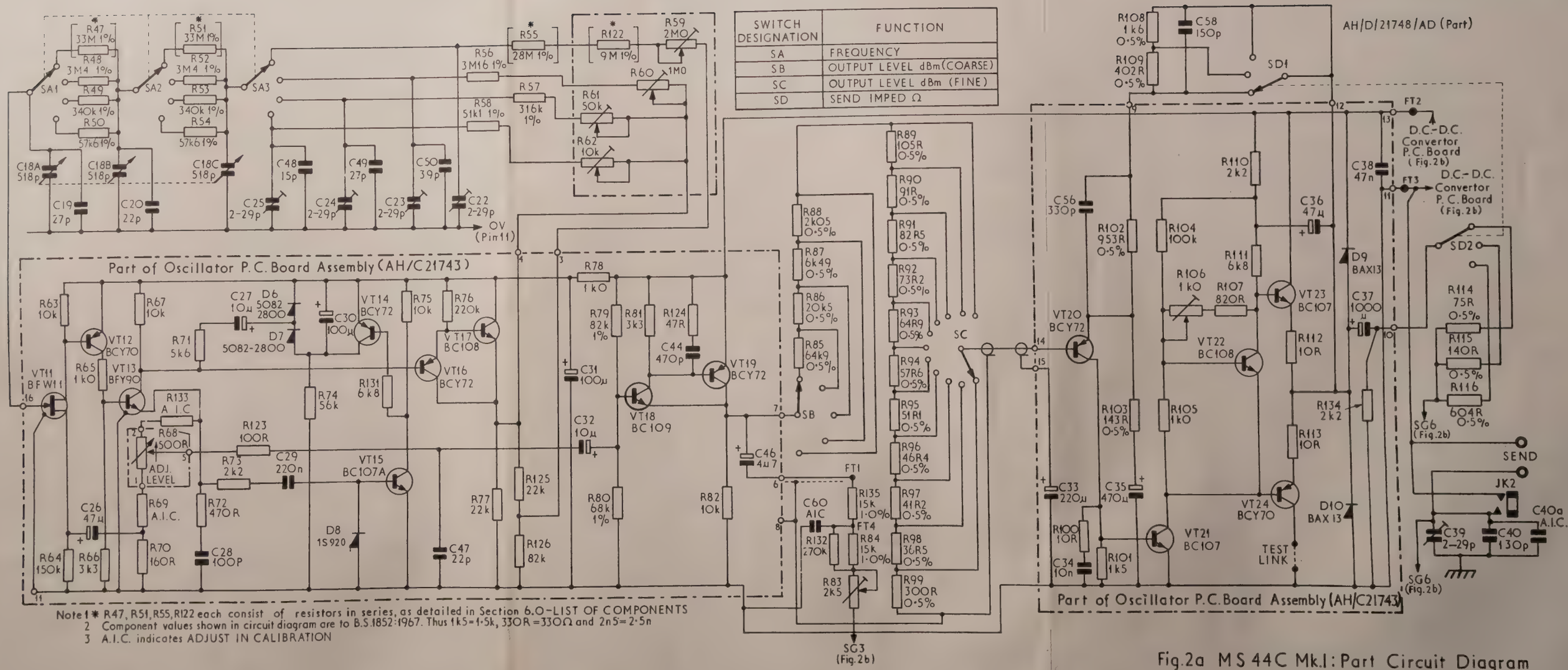
(1) Phase Shift Network

The operating frequency of the oscillator is the frequency at which 180° phase shift occurs in the phase shift network. The network comprises three sections, each having equal value components.

Frequency control is provided by the three-gang, air-spaced capacitor (C18A, C18B and C18C) in conjunction with three resistors. The latter are selected by the Frequency switch (SA1, SA2 and SA3). Preset controls are provided to enable the frequency to be set to coincide with the dial markings; these are R59 to R62 inc. and C22 to C25 inc. Adjustment of these controls is described in Section 4.0 SETTING UP INSTRUCTIONS.

(2) Maintaining Amplifier

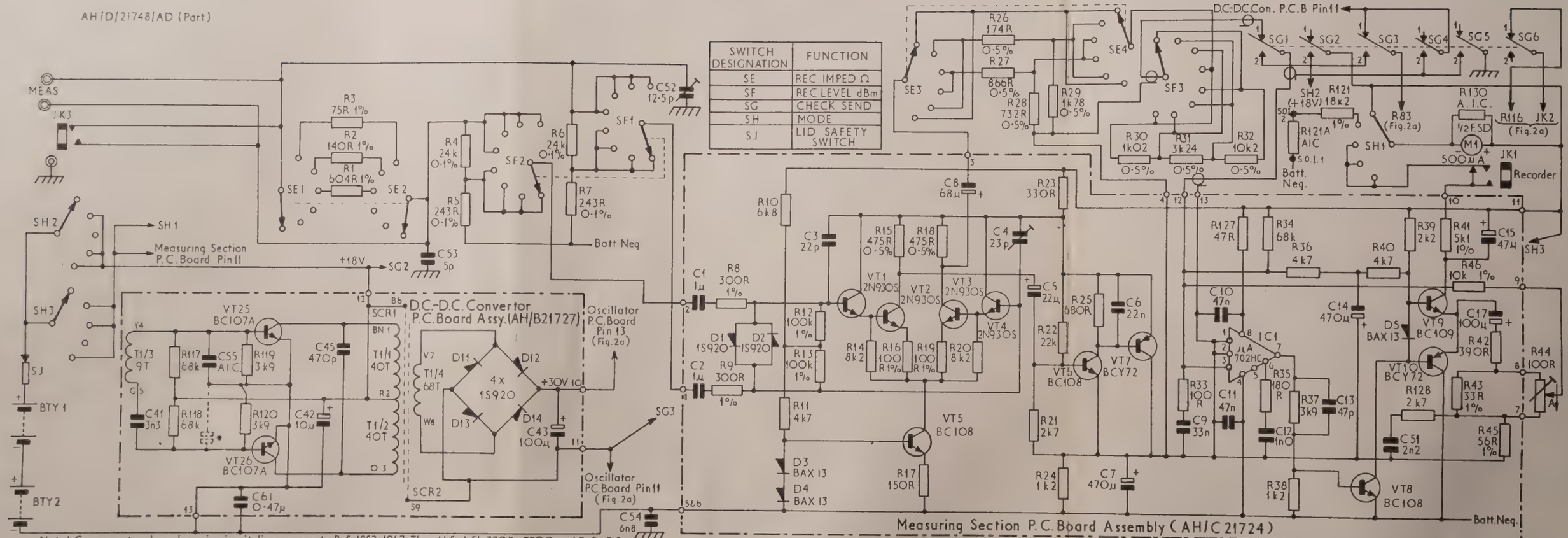
The maintaining amplifier is required to present a high impedance load to the output of the phase shift network, and so a field effect transistor (VT11) is used for the



Note 1 * R47, R51, R55, R122 each consist of resistors in series, as detailed in Section 6.0 – LIST OF COMPONENTS
2 Component values shown in circuit diagram are to B.S.1852:1967. Thus 1k5 = 1·5k, 330R = 330Ω and 2n5 = 2·5n
3 A.I.C. indicates ADJUST IN CALIBRATION

Fig.2a MS 44C Mk.1: Part Circuit Diagram

AH/D/21748/AD (Part)



SWITCH DESIGNATION	FUNCTION
SE	REC IMPED Ω
SF	REC LEVEL dBm
SG	CHECK SEND
SH	MODE
SJ	LID SAFETY SWITCH

Note 1. Component values shown in circuit diagram are to B.S.1852:1967. Thus 1k5=1·5k, 330R=330Ω and 2n5=2·5n

2 * Alternative position for C55

3 A.I.C Indicates ADJUST IN CALIBRATION

Fig.2b MS 44C Mk.1: Part Circuit Diagram

first stage; this is followed by two further stages of amplification (VT12 and VT13). Feedback is applied from the junction of R69 and R70, via C26, to the source of VT11; this produces a defined voltage gain for the three stages.

An output is taken from the collector of VT13 and fed to the compound emitter follower VT16 and VT17; this produces the required low output impedance for driving the phase shift network.

A further output is taken from the emitter of VT13 via the ADJ LEVEL control R68; this drives a further compound follower VT18 and VT19, which in turn provides an output to the attenuator networks and the monitoring circuit. The ADJ LEVEL control provides a ±2dB adjustment and is used in conjunction with the CHECK SEND key, to calibrate the SEND output level.

The maintaining amplifier provides the required 180° phase shift between its input and the output to the phase shift network.

(3) Amplitude Stabilisation Circuit

The gain of the maintaining amplifier must be equal to the attenuation in the phase shift network. This is achieved by an amplitude stabilisation circuit or A. G. C. loop. The circuit functions as follows:

A signal is fed from the emitter of VT13, via R73 and C29, to the base of VT15. VT15 is not provided with forward bias and therefore requires a positive going signal before collector current can flow. D8 limits the negative base excursion to approximately 600mV. On positive signal crests of greater than 600mV approx., VT15 conducts and in turn causes VT14 to conduct; this causes C30 to become partially discharged. With a

sufficiently large signal at the base of VT15, the voltage across C30 is reduced to the point where D6 and D7 conduct on signal peaks. R71 is then placed in parallel with R67 and the waveform at the collector of VT13 becomes clipped. The amplitude stabilisation circuit operates by adjusting the degree of clipping. This distorted waveform is fed to the phase shift network, but because of the selective nature of the network, the harmonics are greatly attenuated compared to the fundamental and a good sine wave is presented to the gate of VT11. A good sine wave also appears at the emitter of VT13; this is fed to the attenuator network via the compound follower VT18 and VT19.

3.2.3 Attenuator Network (OUTPUT LEVEL dBm)

The upper arm of the attenuator chain is switched by SB to give five steps of 10dB, while the lower arm is tapped at eleven positions by SC to give steps of 1dB. The output from the wiper of SC is taken to the input of the output amplifier.

3.2.4 Output Amplifier

The output amplifier has three stages: a pre-amplifier (VT20), a driver (VT21)and a complementary push-pull output pair (VT23 and VT24). Overall negative feedback is applied from the junction of R112 and R113, via R108, R109 (when switched into circuit by SD1) and R102, to the emitter of VT20. SD2 selects one of three series resistors R114, R115 and R116 to give three alternative output impedances, while SD1 provides three alternative output levels - one for each output impedance.

VT22 provides forward bias for VT23 and VT24, and corrects for Vbe drift caused by temperature changes. R106 is provided for adjustment of quiescent current, while R104 ensures that this quiescent current remains constant with changing supply voltage. D9 and D10 protect the circuit against the possibility of high voltages being accidentally connected to the SEND terminals. Forward bias for VT20 is obtained from the compound follower VT18/VT19 via the attenuator network.

C33, C35 and C37 are d.c. blocking capacitors.

The entire sending section is powered from a 30V floating supply obtained from the d.c. - d.c. convertor.

3.3 D. C. - D. C. CONVERTOR

A circuit diagram of the d.c. - d.c. convertor is given in Fig. 2(b).

The convertor consists of two transistors, VT25 and VT26, operating at a nominal frequency of 20kHz. T1 is double screened to prevent the convertor frequency from entering the sending circuit. One screen (SCR1) is returned to the positive battery supply, the second (SCR2) to the floating 0V supply of the oscillator circuit. The transistors switch alternately, oscillation being maintained by positive feedback derived from the feedback winding T1/3. The switching rate is defined by C41 in conjunction with R119/R120. R117/R118 provide a small forward bias to enable the circuit to start. C45 prevents high frequency oscillation, while C42 eliminates convertor ripple which might otherwise affect the supply to the level measuring section. The output from T1/4 is fed to the bridge rectifier D11 - D14 and hence to the reservoir capacitor C43.

3.4 LEVEL MEASURING SECTION

A circuit diagram of the level measuring section is given in Fig. 2(b).

The input circuit balance is obtained by use of a differential amplifier. The balance at low frequencies is further improved by floating the entire circuit, including the batteries, with respect to the instrument case. C54 couples the case to the negative supply line at higher frequencies.

A signal at the MEASURE terminals is presented to the input of the differential amplifier via terminating and attenuating networks. The differential amplifier comprises two Darlington connected pairs (VT1 and VT4) and a constant current source (VT5). An additional amplifier consisting of VT6 and VT7 senses the voltage at the collector of VT2 and, by means of negative feedback, controls the supply to the

differential amplifier such as to produce a virtual earth at the collector of VT2; this reduces the effects of longitudinal voltages existing at the input.

An input protection circuit comprising D1, D2, R8 and R9, is included to minimise the possibility of damage occurring in the event of accidental connection to high voltages; C1, C2 provide d.c. blocking.

C52 and C53 enable input balance to be maintained at high frequencies by equalising wiring capacities; C3 and C4 perform the same function for the amplifier.

The output from the differential amplifier is taken from the collector of VT3, via C8, to the switched attenuator formed by SE3, SE4 and R26 to R29. This attenuator circuit is part of the REC IMPED Ω switch; its purpose is to produce three levels of overall gain corresponding to the three input impedances switched by SE1 and SE2. The signal is then fed to a further attenuator selected by SF3; this is ganged with the input attenuator selected by SF1 and SF2, to create the 10dB steps of the REC LEVEL dBm switch.

The output at the wiper of SF3 is taken, via screened cables and a normally closed contact on the CHECK SEND key SG, to the input of IC1. The integrated circuit requires -ve and +ve supplies for correct operation, so an artificial 0V line is created by passing the current drawn by VT6 and VT7 through R24; this is bypassed by C7. The output from IC1 is further amplified by VT8 before application to the detector - formed by VT9 and VT10.

The detector operates in class B with zero quiescent current. The 'dead zone' between the conduction of VT9 and VT10 is reduced to approximately 600mV by the inclusion of D5 into the bias chain. This reduces the required signal swing. The emitter currents of VT9 and VT10 flow through C17 and a load formed by R42 to R45. Negative feedback is applied over the whole circuit from the slider of R44, via R46, to the input of the integrated circuit. D. C. feedback is applied via R36 and R40, the a.c. component being decoupled by C14.

In the three operating positions of the Mode switch SH, the detector output is fed via R41 and the shorting jack JK1 to the negative terminal of M1. R41 ensures that the output impedance is greater than 5kΩ, while C15 reduces the output ripple.

When the CHECK SEND key SG is depressed, the output from the compound follower VT18 and VT19 is fed via C46, R84, R83, SG3 and SG1 to the input of IC1; this enables the oscillator level to be monitored and adjusted by means of the ADJ LEVEL control R68. During monitoring, the output from the differential input amplifier is disconnected by SG1, while the oscillator negative supply is linked to the 0V line of the Level Measuring Section and chassis by SG4 and SG5. The oscillator output is now unbalanced, so the SEND terminals and associated jack are disconnected by means of SG6. SG2 supplies power to the Level Measuring Section when the CHECK SEND key is depressed.

SH2 connects power to the d.c.-d.c. convertor in the OSC ONLY and ON positions, while SH3 connects power to the Level Measuring Section in the LMS ONLY and ON positions. SH1 and SH3 switch M1 to measure battery voltage in the CHECK BATT position via R121. The circuit is arranged so that the meter indicates in the REPLACE BATTERY sector when the voltage falls to 13.2 volts (1.1 volt per cell).

Two preset controls, A and B, are accessible from the front panel. 'A' (R44) is used to adjust the overall sensitivity of the Level Measuring Section, while 'B'(R83) is used to give the correct output level from the oscillator when the CHECK SEND key is depressed. Both controls are adjusted during the setting up procedure and should not be adjusted by the user.

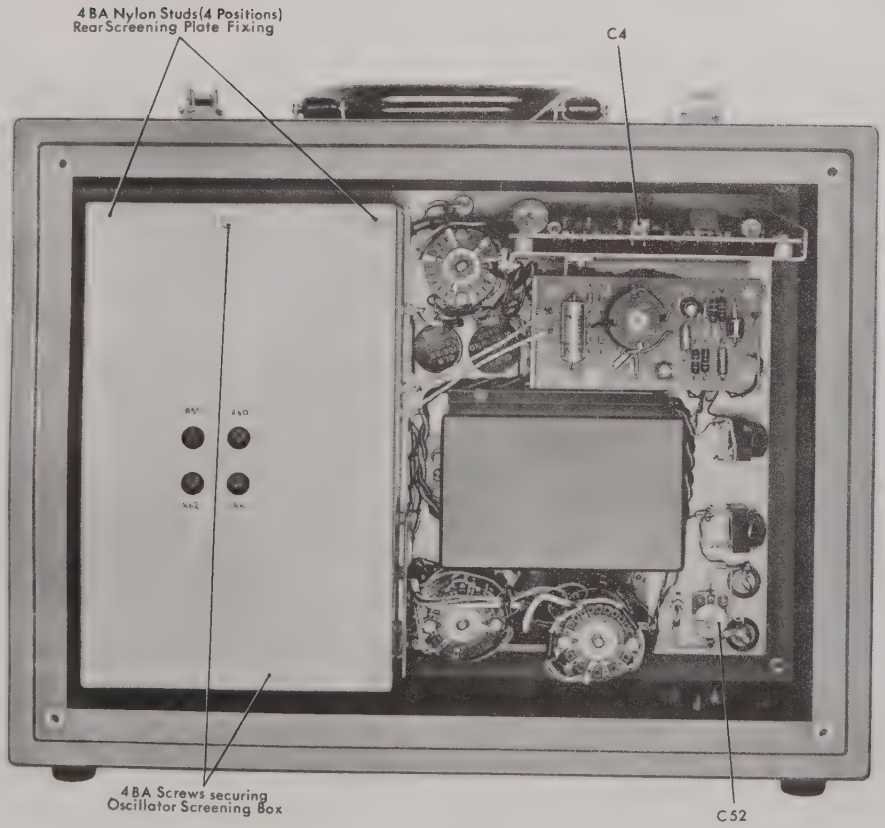


Fig.3 Rear View with Panel and Oscillator Screening Plate removed

4.0 SETTING UP INSTRUCTIONS

4.1 GENERAL

The following paragraphs give complete instructions for the adjustment of all preset controls in the instrument, and check that the performance meets the specification.

A general view of the rear of the instrument is shown in Fig. 3 and a more detailed view is given in Fig. 5. Details of the printed circuit boards are shown on Figs. 4, 6 and 11.

4.2 TEST EQUIPMENT REQUIRED

The following items of test equipment are required to facilitate the setting up procedure.

A. F. Signal Generator

Frequency Range:	20Hz to 120kHz
Output Level:	Continuously adjustable over the range 0.8mV to 2.8V into 12kΩ load. To generate at least 550mV into 150Ω load.

R. F. Oscillator

Frequency:	200kHz ±2%
Output Level:	2.0V into 12K load.

Wideband Voltmeter

Frequency Range:	20Hz to 120kHz
Level Range:	0.3mV to 3.1V
Accuracy:	0.25% of reading.

Digital Voltmeter

Voltage Range:	0.25 to 1.0V D.C.
Input Impedance:	>3MΩ
Accuracy:	±0.1% of reading.

Timer/Counter

Period Range:	0.5mS to 50mS
Frequency Range:	2kHz to 120kHz
Input Sensitivity:	250mV
Accuracy:	±0.03%

D. C. Power Supply

Output Voltage:	Continuously variable 13 to 18V
Output Current:	60mA
Output Impedance:	<1Ω d.c. to 200kHz

D. C. Voltmeter

Voltage Range:	13 to 30V
Accuracy:	±0.05V

D. C. Milliammeter

Current Range:	0-30mA
Accuracy	±0.5mA

Load Resistor

Non-reactive resistors (metal film or similar) one each of the following values.	600Ω ±1% - centre tapped ±0.1% 600Ω ±0.1% 140Ω ±0.1% 75Ω ±0.1% 900Ω ±1% 1kΩ ±0.1%

Selective Rejector

Balanced 600Ω input. To provide at least 55dB attenuation at 800Hz, <1dB in the range 1.6-120kHz, and at least 10dB from 1MHz upwards.

Jack Plug

3-way P.O. type Jack Plug with flying leads connected to Tip and Ring.

Continuity Tester

To measure circuit resistance of less than 100Ω.

Batteries

2 batteries, Ever-Ready type PP9 or equivalent.

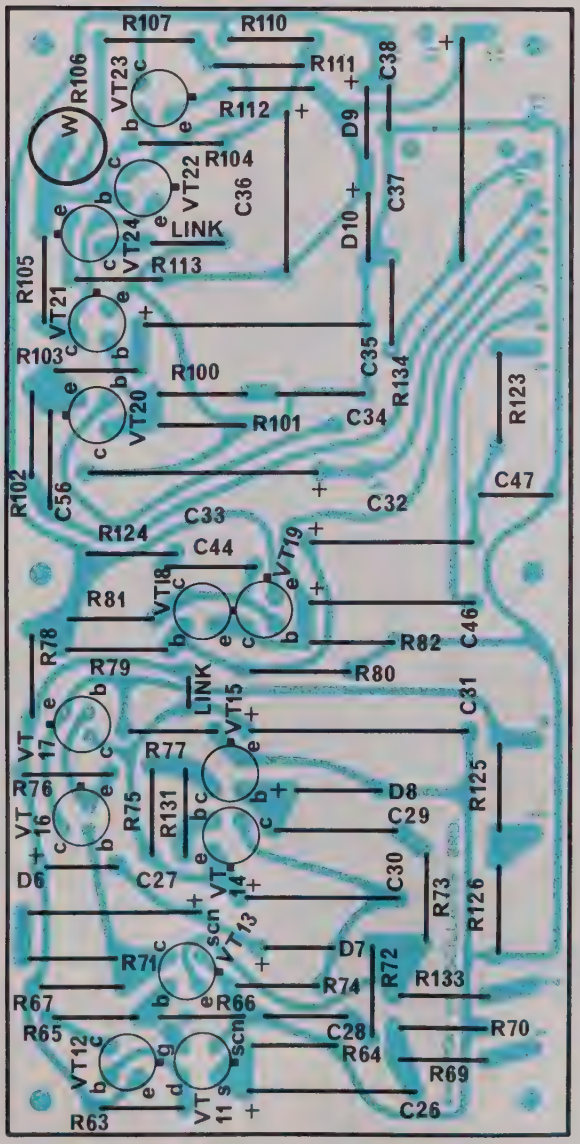


Fig.4 Oscillator Board

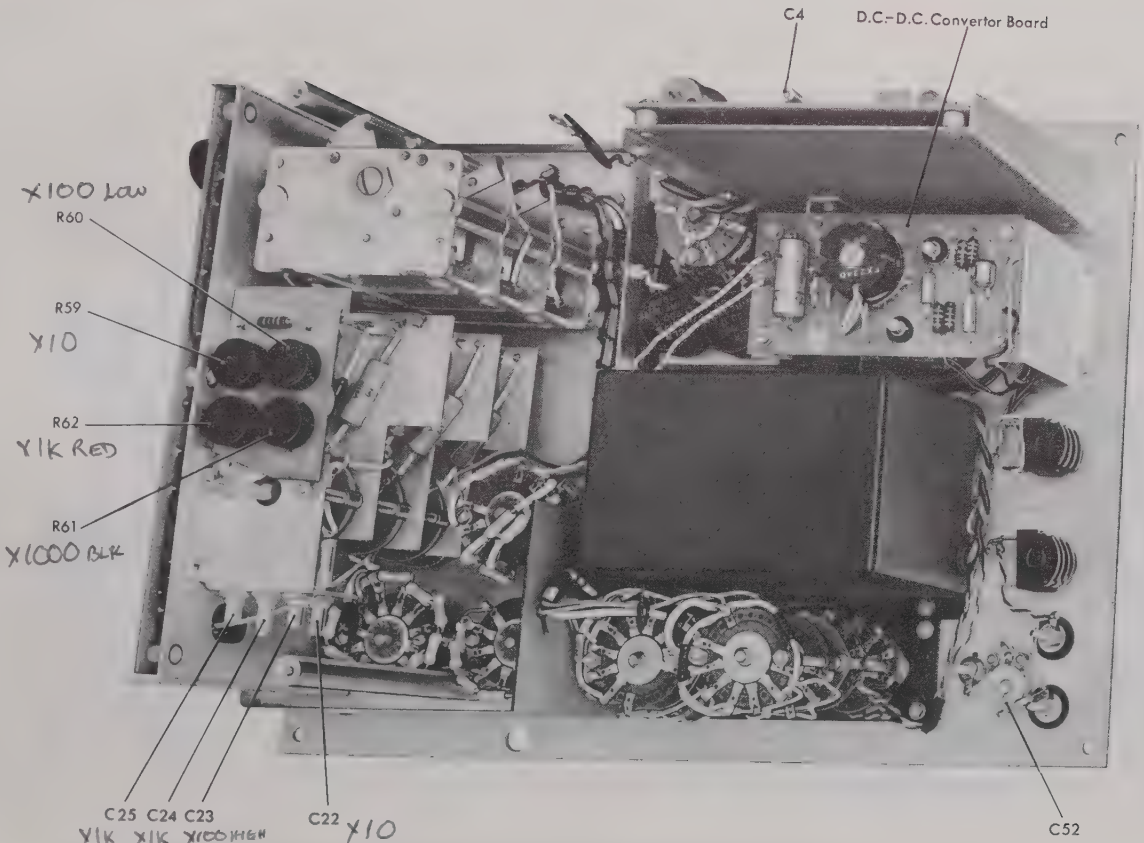


Fig.5 General View of Instrument Assembly(Oscillator Screening Cover removed)

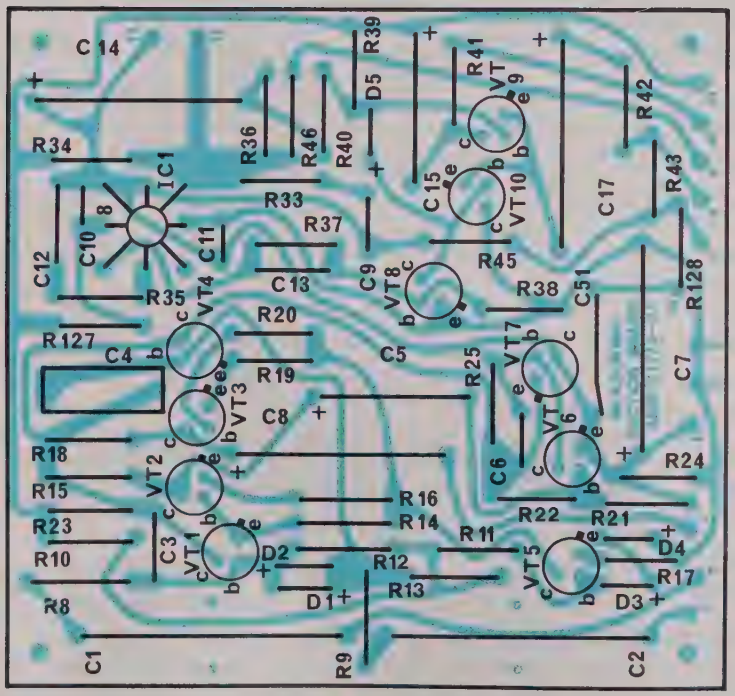


Fig.6 Level Measuring Board

4.3 DISMANTLING THE INSTRUMENT

4.3.1 General

Some of the following operations require that the instrument be removed from its case, others require removal of the rear panel only; in a few instances, adjustments are made with the instrument fully assembled.

4.3.2 Removing the Instrument from its Case

To remove the entire instrument and front panel assembly, lay the cabinet on a bench with the face uppermost and remove the four 2BA screws with washers - one at each corner - securing the front panel to the cabinet; lift the assembly clear of the case. The rear panel is secured in a similar manner. R59, 60, 61 and 62, also C22, 23, 24 and 25 are now accessible.

4.3.3 Removing the Oscillator Screening Box & Rear Screening Plate

Having removed the instrument assembly from its case, lay the assembly face down on a soft surface. Disconnect the earthing link by removing the 6BA screw and washer securing the solder tag to the bush on the rear screening plate.

To remove the oscillator screening box, remove the two 4BA screws with washers (illustrated in Fig. 3) and carefully lift the box clear of the oscillator section; R106 is now accessible (see Fig. 4).

4.3.4 Removing the Frequency Control Knob (Hz)

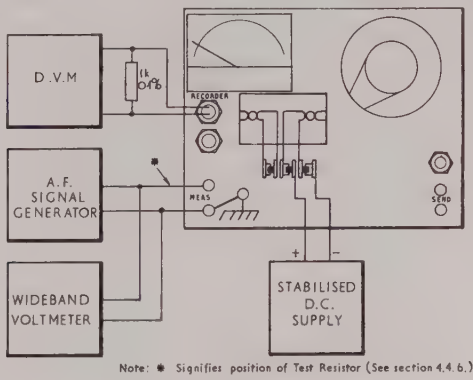
Grip the control knob firmly with one hand and, using a rubber 'sucker' or the ball of the thumb of the other hand, turn the large headed screw in the centre of the knob in a counter-clockwise direction. Remove the screw and pull off the control knob. C39 is now accessible through the hole in the cursor (when set to 120).

4.4 LEVEL MEASURING SECTION

4.4.1 Connections

Connect the instrument under test according to the test circuit shown

in Fig. 7. Note that one pair of battery leads are connected together and the other pair to the stabilised supply. The positive lead of the DVM should be connected to the tip of the Recorder Jack.



Note: * Signifies position of Test Resistor (See section 4.4.6.)

Fig.7 Test Circuit–Measure Section

4.4.2 Setting the Meter Zero

Set the Power Supply to 18 ±0.1V and the controls as follows:

Function	LMS only
REC IMPED Ω	600 Thro
REC LEVEL dBm	0

Apply an input signal at 800Hz at a level of 775mV (or 0dB) as indicated by the Wideband Voltmeter. Rotate the preset control 'A' on the front panel to obtain a reading of 500mV ±0.1% and ensure that the meter indicates a level of 0dB ±0.1dB.

4.4.3 Frequency Response

Set the input frequency to 30Hz, maintaining the level at 775mV. The DVM should indicate between 489 and 511mV.

Set the input frequency to 120kHz, maintaining the level at 775mV. The DVM should indicate between 489 and 511mV.

4.4.4 Linearity

Set the input frequency to 800Hz, at each level in turn as shown in Table 1. In each case check that the DVM reading is within ±1% of the value shown. Also check that the reading of Meter M1 corresponds to the input level ±0.1dB between ±3dB or ±0.2dB between ±3dB to ±6dB.

Input Level		D. V. M.
Volts	dB	reading (mV)
0.388	-6	251
0.489	-4	316
0.615	-2	397
0.775	0	500
0.975	+2	629
1.228	+4	792
1.546	+6	998

Table 1. Input/Output Levels for Linearity Test

4.4.5 Impedance Switching (Through)

Set the input level to 374mV at 800Hz and REC IMPED Ω to 140 THRO. The DVM should indicate 500mV ±1%.

Set the input level to 274mV at 800Hz and REC IMPED Ω to 75 THRO. The DVM should indicate 500mV ±1%.

4.4.6 Impedance Switching (Terminated)

Connect resistors of value 600Ω ±0.1%, 140Ω ±0.1% and 75Ω ±0.1% in turn (as shown in Table 2), between the Signal Generator output and the upper MEAS terminal (see Fig. 7). Set REC IMPED Ω and Generator Voltage to the settings shown in Table 2. In each case the DVM should indicate 500mV ± 1%.

Series Resistor	Generator Output	REC IMPED Ω
600Ω	1.56V	600 TERM
140Ω	0.75V	140 TERM
75Ω	0.55V	75 TERM

Table 2. Test Conditions for Impedance Switching Test

4.4.7 Receive Level

Connect the Signal Generator directly to MEAS terminals as shown in Fig. 7. Set REC IMPED Ω to 75 THRO and REC LEVEL dBm to 0dB. Set the input to 274mV at 800Hz and adjust the preset control 'A' for a DVM reading of 500mV ±0.1%. Set REC LEVEL dBm and input signal level to the settings shown in Table 3. In each case check that the DVM reads 500mV ±2%.

REC LEVEL dBm	Signal Level (mV)
+20	2740
+10	866
0	274
-10	86.6
-20	27.4
-30	8.66
-40	2.74
-50	0.866

Table 3. Test Conditions for Receive Level Test

4.4.8 Recorder Ripple

Set REC LEVEL dBm to 0dB. Set the input frequency to 20Hz at a level of 274mV. Using the Wideband Voltmeter, measure the a.c. signal across the 1kΩ recorder load. Check that this does not exceed 50mV. .

4.4.9 Balance

Connect the instrument under test according to the test circuit shown in Fig. 8. Set the R.F. Oscillator output to 2V r.m.s. ±1% at 200kHz. Set REC IMPED Ω to 600 THRO and REC LEVEL dBm to -50dB. Temporarily link together MEAS terminals, and adjust C4 (Level Measuring Board) for a minimum reading on the DVM. Check that this reading is less than 160mV. Remove the temporary link between MEAS terminals and adjust C52 (adjacent to MEAS terminals) for a minimum reading on the DVM. Check that this reading is less than 160mV. Set REC IMPED Ω control to each position in turn as shown in Table 4. In each case check that the DVM reading is below the limit indicated.

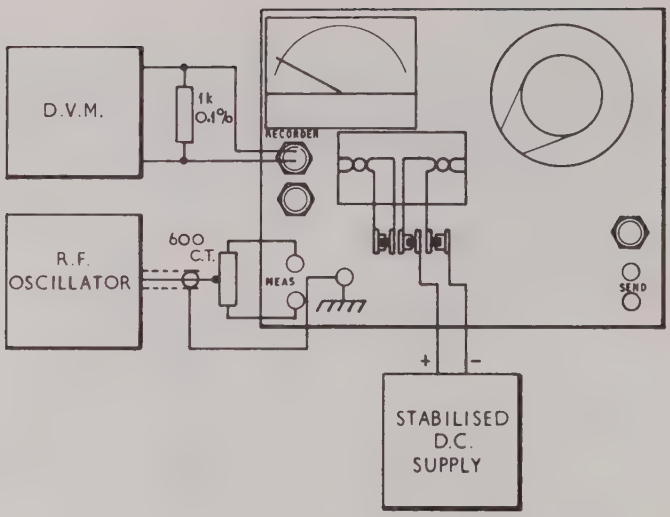


Fig. 8 Test Circuit Measure Balance

REC IMPED Ω	Max Reading (mV)
75 THRO	450
140 THRO	330
600 THRO	160
600 TERM	160
140 TERM	330
75 TERM	450

Table 4. Test Conditions for Measure Balance Test

4. 4. 10 Supply Changes

Connect the instrument under test to the test circuit as shown in Fig. 7. Set the Power Supply to 18 ±0.1V and the controls as follows:

Function	LMS only
REC IMPED Ω	600 THRO
REC LEVEL dBm	0

Apply an 800Hz input signal at a level of approximately 775mV, and

adjust the level for a DVM reading of 500mV. Reduce the supply voltage to 13.2 ±0.1V and check that the DVM reading changes by less than 2%.

4. 4. 11 Recorder Impedance

Insert a 900Ω ±1% resistor in series with the Recorder Output. With the Power Supply voltage at 13.2V, check that the DVM reading changes by less than 1%. Disconnect the test circuit.

4. 5 D. C. - D. C. CONVERTOR

Remove the instrument assembly from its case and remove the oscillator screening box (complete with screening plate). Set R106 (see Fig. 4) fully counter-clockwise. Connect the Power Supply only (as shown in Fig. 7), and set the output voltage to 18V ±0.1V. Connect a d.c. voltmeter between pin 10 (+ve) and pin 11 (-ve) of the D. C. - D. C. Convertor Board and set the Function switch to OSC ONLY. Check that the voltmeter indicates between the limits 27.5 and 30.0V. Remove the voltmeter.

4. 6 OSCILLATOR SECTION

4. 6. 1 Quiescent Current

Set OUTPUT LEVEL dBm controls to -30dB and -10dB. Remove the test link from the oscillator P. C. Board (see Fig. 4) and, in place of the link, connect a Milliammeter. With the Power Supply voltage set at 18V ±0.1V and the Function switch set to OSC ONLY, adjust R106 until the Milliammeter indicates 2mA ±10%. Remove the Milliammeter and replace the test link. Refit the oscillator screening box.

4. 6. 2 Cursor Alignment

If the coupling to the main tuning capacitor has been disturbed, the cursor must be re-aligned as follows.

Remove the Frequency control knob (Hz) as described in Section 4.3.4. Turn the dial fully counter-clockwise against the stop. Note that due to the anti-backlash gears, the dial should spring back slightly when

the knob is released. In this position, align the cursor line exactly with the '2' mark on the scale as follows:

Slacken the two 8BA screws beneath the control knob and rotate the cursor securing disc in the required direction. Tighten the screws and replace the control knob.

4. 6. 3 Send Output

Connect a 600Ω ±0.1% resistor, Wideband Voltmeter and Oscilloscope across SEND terminals. Set the controls as follows:

FREQUENCY	x100
Hz	8
OUTPUT LEVEL dBm (left)	0dB
OUTPUT LEVEL dBm (right)	0dB
SEND IMPED Ω	600
Function	OSC ONLY

Check that the output is approximately sinusoidal. Use ADJ to set the level to 775mV (0dB). Depress CHECK SEND key and adjust the preset control 'B' to obtain a reading of 0dB on the meter. Note that operation of CHECK SEND key disconnects the output to SEND terminals.

Disconnect the 600Ω ±0.1% resistor and, in its place, connect a 140Ω ±0.1% resistor. Set SEND IMPED Ω control to 140 and check that the Wideband Voltmeter indicates 374mV ±1%.

Replace the 140Ω load with a 75Ω ±0.1% resistor. Set SEND IMPED Ω control to 75 and check that the Wideband Voltmeter reads 274mV ±1%.

4. 6. 4 Frequency Setting

If the frequencies on any range are outside specification, proceed as follows:

Ensure that the oscillator screening cover is in position.

Connect a Frequency Counter to the SEND terminals, the counter being set to measure Period. Set FREQUENCY control to x10 and the Hz dial to 2. Adjust R59 (see Fig. 3) to obtain a counter reading of 50mS ±0.5%. Set Hz dial to 20 and with the aid of an insulating trimmer tool,

adjust C22 (see Fig. 5) to obtain a counter reading of 5.0mS ±0.5%. Repeat these two operations until both ends of the scale are correct. Set the frequency to each setting shown in Table 5, in each case checking that the counter reading is within the limits shown. If the intermediate values are out of specification, the ends of the scale may be set slightly high or low within the limits shown in Table 5, by re-adjustment of R59 and C22.

Repeat this procedure for the other three ranges, setting the counter to measure frequency on the two highest frequency ranges.

x100 Range	adjust R60 and C23
x1000 Range	adjust R61 and C24
x1000 Range (red)	adjust R62 and C25

Range	Dial Setting	Counter Reading	
		Min.	Max.
x10	2	47.7mS	52.6mS
	3	32.3mS	34.4mS
	5	19.7mS	20.4mS
	8	12.35mS	12.65mS
	12.5	7.92mS	8.08mS
	20	4.95mS	5.05mS
x100	2	4.95mS	5.05mS
	3	3.30mS	3.37mS
	5	1.98mS	2.02mS
	8	1.238mS	1.262mS
	12.5	792µS	808µS
	20	495µS	505µS
x1000	2	1.98kHz	2.02kHz
	3	2.97kHz	3.03kHz
	5	4.95kHz	5.05kHz
	8	7.92kHz	8.08kHz
	12.5	12.37kHz	12.62kHz
	20	19.8kHz	20.2kHz
x1000 Red	12	11.88kHz	12.12kHz
	18	17.82kHz	18.18kHz
	30	29.7kHz	30.3kHz
	50	49.5kHz	50.5kHz
	80	79.2kHz	80.8kHz
	120	118.8kHz	121.2kHz

Table 5 Frequency Setting

4.6.5 Send Level

Connect a 600Ω ±0.1% resistor and Wideband Voltmeter across SEND terminals. Set the controls as follows:

FREQUENCY	x100
Hz	8
OUTPUT LEVEL dBm (left)	0dB
OUTPUT LEVEL dBm (right)	0dB
SEND IMPED Ω	600
Function	OSC ONLY

With the Power Supply set to give an output of 18V ±0.1%, set ADJ control to produce a reading of 775mV (0dB) on the Wideband Voltmeter.

Set OUTPUT LEVEL dBm controls, in turn, to the positions shown in Table 6. In each case check that the Wideband Voltmeter indicates within the limits shown.

OUTPUT LEVEL dBm		OUTPUT LEVEL
Left	Right	(mV)
+10	0	2450 ±1%
0	0	775 ±1%
-10	0	245 ±1%
-20	0	77.5 ±1%
-30	0	24.5 ±1%
0	-1	691 ±1%
0	-2	616 ±1%
0	-3	549 ±1%
0	-4	489 ±1%
0	-5	436 ±1%
0	-6	388 ±1%
0	-7	346 ±1%
0	-8	308.5 ±1%
0	-9	275.0 ±1%
0	-10	245.0 ±1%

Table 6 Send Level

4.6.6 Frequency Response

Reset both OUTPUT LEVEL dBm controls to the 0dB positions and check that the Wideband Voltmeter indicates 775mV (0dB) at the SEND frequency of 800Hz. Correct with ADJ control if necessary.

Set the output frequency to each of the following settings in turn; in each case check that the Wideband Voltmeter indicates 775mV ±2%.

x10 Range	20Hz	200Hz
x100 Range	200Hz	2kHz
x1000 Range	2kHz	20kHz
x1000 Range (red)	12kHz	120kHz

4.6.7 Output Balance

Fit the instrument under test into its case and check that there is electrical continuity between the red EARTH terminal and any one of the rear panel securing screws. Fit two batteries type PP9 to the instrument and connect according to the test circuit shown in Fig. 9. Set the Frequency to 120kHz and the Output Level to +10dB. Remove the Frequency control knob (see Section 4.3.4) to obtain access to C39 through the hole in the cursor. Adjust C39 for a minimum reading on the Wideband Voltmeter. Check that this reading is less than 2.45mV (-50dB).

NOTE: If the range of C39 is inadequate, the value of C40 may be increased or decreased as necessary.

4.6.8 Noise and Distortion

Connect the instrument to the test circuit of Fig. 10. Set the controls as follows:

FREQUENCY	x100
Hz	8
OUTPUT LEVEL dBm (left)	-30dB
OUTPUT LEVEL dBm (right)	-10dB
SEND IMPED Ω	600
Function	OSC ONLY

Depress CHECK SEND key and set ADJ control to give a meter reading of 0dB. Adjust the output frequency to obtain minimum indication on the Wideband Voltmeter. At null, the reading should not exceed 345μV (-67dB). Change OUTPUT LEVEL dBm (left) to +10dB and change OUTPUT LEVEL dBm (right) to 0dB. Adjust the output

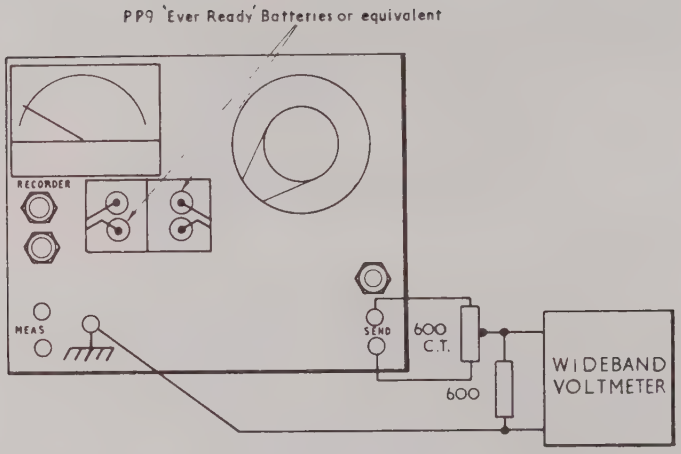


Fig.9 Test Circuit – Send Balance

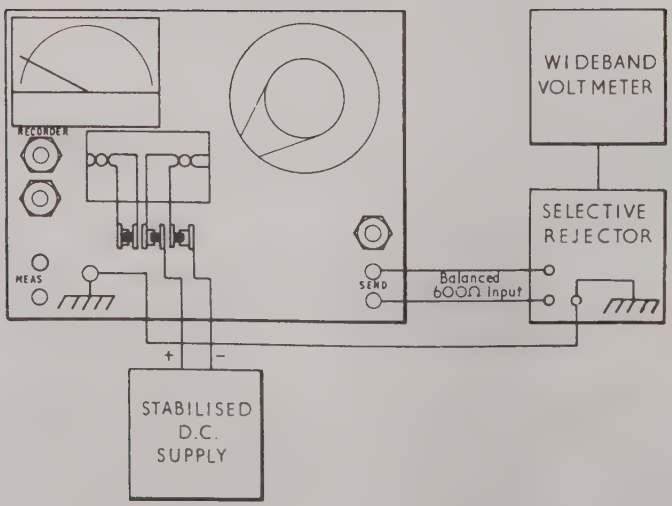


Fig.10 Test Circuit – Noise & Distortion

frequency to obtain minimum indication on the Wideband Voltmeter. At null, the reading should not exceed 43.5mV (-25dB).

4. 6. 9 Oscillator Pick-up

Connect the instrument as shown in Fig. 7. Connect a 600Ω resistor between SEND terminals and set the controls as follows:

FREQUENCY	x1000 (red)
Hz	120
OUTPUT LEVEL dBm (left)	+10dB
OUTPUT LEVEL dBm (right)	0dB
SEND IMPED Ω	600
REC IMPED Ω	600 THRO
REC LEVEL dBm	-50dB
Function	LMS ONLY

Set the Power Supply output to 18V ±0.1V. Set the Signal Generator to give an output of 2.45mV at 800Hz, then readjust the level until the DVM indicates 500mV. Set the Function control to ON and observe the DVM reading; this should not increase by more than 1%.

4. 6. 10 Battery Check

Set the Function control to CHECK BATT. Adjust the Power Supply voltage until the Meter reads exactly on the REPLACE BATTERY mark. Check that the supply voltage is between the limits 13.0 and 13.4V.

4. 6. 11 Supply Current

Set the front panel controls to the positions stated in Section 4. 6. 9. Connect a d.c. milliammeter in series with the Power Supply (set to 18V ±0.1V), to monitor the current drawn by the Level Measuring Section. The meter indication should not exceed 30mA.

Set the Function switch to OSC ONLY. The milliammeter will now monitor the current drawn by the Sending Section. The meter indication should not exceed 30mA.

Remove all leads from SEND and MEAS terminals.

4.6.12 Lid Switch

With the milliammeter indicating the current drawn by the Sending Section, pass the supply leads towards the top of the instrument and fit the lid. Check that when the lid is within 1/8" of the closed position, the supply current drops to zero.

Remove the lid, then disconnect the Power Supply and milliammeter.

4.6.13 Jack Continuity

By means of a Jack Plug inserted into the appropriate Jack, ensure electrical continuity between the following points:

MEAS Jack	Tip	Lower MEAS terminal
	Ring	Upper MEAS terminal
SEND Jack	Tip	Upper SEND terminal
	Ring	Lower SEND terminal

4.6.14 Supply Changes

Connect a 600Ω ±0.1% resistor, Wideband Voltmeter and counter to SEND terminals. Set the controls as follows:

FREQUENCY	x1000 (red)
Hz	120
OUTPUT LEVEL dBm (left)	0dB
OUTPUT LEVEL dBm (right)	0dB
SEND IMPED Ω	600
Function	OSC ONLY

Connect the Power Supply and set the output voltage to 18V ±0.1V. Adjust the output frequency (as indicated by the counter) to exactly 120kHz and the output level to 775mV. Reduce the supply voltage to 13.2 ±0.1V. Check that the level change does not exceed 2% and that the frequency change does not exceed 1%.

NOTE: OUTPUT BALANCE

If the instrument has been removed from its case, the Output Balance procedure should be repeated (see Section 4.6.7).

5.0 TEST VOLTAGES

The figures given below were obtained using an Avometer Model 8, set to the stated range, and under the stipulated test conditions. The voltage values are typical and may vary within the range ±10%.

Sending Section - measured under the following test conditions:

Frequency 800Hz. Output level -40dB. Send Impedance 75Ω.
Function switch set to OSC. ONLY. Power Supply 18V ±0.1V.
No load on SEND terminals. Meter negative lead connected to pin 11.

Measurement point		Meter range	Indicated voltage (+ve)
	s	100V	9V
VT11	g	-	-
	d	100V	24V
	e	100V	25V
VT12	b	see VT11 drain	-
	c	10V	3.4V
	e	10V	1.9V
VT13	b	10V	2.6V
	c	25V	7.4V
	e	see VT12 emitter	-
VT14	b	100V	24.5V
	c	100V	22V
	e	-	-
VT15	b	see note on Fig 4	-
	c	see VT14 base	-
	e	25V	8V
VT16	b	see VT13 collector	7.4V
	c	25V	7.4V
	e	see VT16 collector	-
VT17	b	see VT16 emitter	-
	c	see VT12 emitter	-
	e	25V	12.25V
VT18	b	100V	12.5V
	c	100V	28V
	e	100V	28.5V
VT19	b	see VT18 collector	-
	c	see VT18 emitter	-
	e	100V	13V
VT20	b	100V	12V
	c	10V	0.65V
	e	-	-
VT21	b	see VT20 collector	-
	c	100V	12.5V
	e	see VT21 collector	-
VT22	b	100V	13V
	c	100V	14V

Sending Section cont'd

Measurement point		Meter range	Indicated voltage (+ve)
VT23	e	100V	13V
	b	see VT22 collector	-
	c	100V	28V
VT24	e	100V	13V
	b	see VT21 collector	-
	c	-	-

D. C. - D. C. Convertor - test conditions as for Sending Section except meter negative lead connected to pin 13 on convertor board.

Measurement point		Meter range	Indicated voltage
VT25	e	-	-
	b	10V	- 0.5V
	c	100V	18V
VT26	e	-	-
	b	10V	- 0.5V
	c	100V	18V

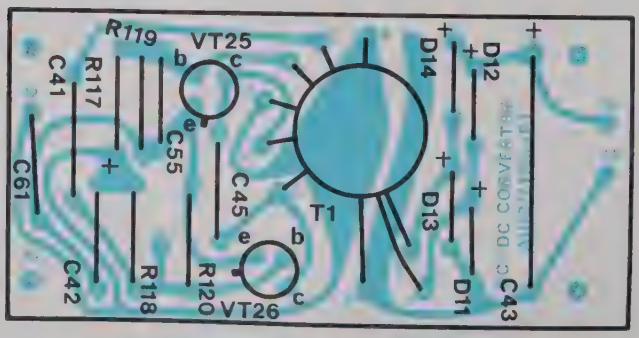


Fig.11 D.C.-D.C. Convertor

Level Measuring Section - measured under the following conditions:

Function switch LMS ONLY. REC IMPED 75Ω. REC LEVEL -50dBm.

Power Supply 18V ±0.1V. No connection to MEAS terminals.

Meter negative lead connected to pin 5 or 6.

Measurement point		Meter range	Indicated voltage
	e	25V	7.5V
VT1	b	100V	7.5V
	c	25V	13.5V
	e	25V	7V
VT2	b	see VT1 emitter	-
	c	25V	12.5V
	e	25V	7V
VT3	b	25V	7.5V
	c	25V	12.5V
	e	see VT3 base	-
VT4	b	100V	8V
	c	25V	13.5V
	e	10V	0.7V
VT5	b	10V	1.35V
	c	25V	6.5V
	e	25V	8V
VT6	b	25V	8.5V
	c	25V	13V
	e	see VT1 collector	-
VT7	b	see VT6 collector	-
	c	see VT6 emitter	-
	1 & 2	see VT6 emitter	-
	3	25V	8V
	4	-	0V
IC1	5	25V	13V
	6	25V	3.5V
	7	25V	3V
	8	100V	17.5V
	e	-	-
VT8	b	10V	0.65V
	c	25V	6V
	e	25V	6.25V
VT9	b	25V	6.75V
	c	100V	17V
	e	see VT9 emitter	-
VT10	b	see VT8 collector	-
	c	-	-

6. 0 LIST OF COMPONENTS

Resistors

Ref	Component				Rating	Man'ftr. & Part No.
R1	604	±1%	50ppm	Metal Film	1W	Welwyn 4036C
R2	140	±1%	50ppm	Metal Film	1W	Welwyn 4036C
R3	75	±1%	50ppm	Metal Film	1W	Welwyn 4036C
R4	24k	±0.1%	50ppm	Metal Film	0.25W	Welwyn 4034C
R5	243	±0.1%	50ppm	Metal Film	0.25W	Welwyn 4034C
R6	24k	±0.1%	50ppm	Metal Film	0.25W	Welwyn 4034C
R7	243	±0.1%	50ppm	Metal Film	0.25W	Welwyn 4034C
R8	300	±1%	50ppm	Metal Film	0.25W	Welwyn 4034C
R9	300	±1%	50ppm	Metal Film	0.25W	Welwyn 4034C
R10	6.8k	±5%		Metal Oxide	0.5W	Welwyn MR5
R11	4.7k	±5%		Metal Oxide	0.5W	Welwyn MR5
R12	100k	±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R13	100k	±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R14	8.2k	±5%		Metal Oxide	0.5W	Welwyn MR5
R15	475	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R16	100	±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R17	150	±5%		Metal Oxide	0.5W	Welwyn MR5
R18	475	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R19	100	±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R20	8.2k	±5%		Metal Oxide	0.5W	Welwyn MR5
R21	2.7k	±5%		Metal Oxide	0.5W	Welwyn MR5
R22	22k	±5%		Metal Oxide	0.5W	Welwyn MR5
R23	330	±5%		Metal Oxide	0.5W	Welwyn MR5
R24	1.2k	±5%		Metal Oxide	0.5W	Welwyn MR5
R25	680	±5%		Metal Oxide	0.5W	Welwyn MR5
R26	174	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R27	866	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R28	732	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R29	1.78k	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R30	1.02k	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R31	3.24k	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C

Resistors continued

Ref	Component			Rating	Man'ftr. & Part No.
R32	10.2k ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R33	100 ±5%		Metal Oxide	0.5W	Welwyn MR5
R34	68k ±5%		Metal Oxide	0.5W	Welwyn MR5
R35	180 ±5%		Metal Oxide	0.5W	Welwyn MR5
R36	4.7k ±5%		Metal Oxide	0.5W	Welwyn MR5
R37	3.9k ±5%		Metal Oxide	0.5W	Welwyn MR5
R38	1.2k ±5%		Metal Oxide	0.5W	Welwyn MR5
R39	2.2k ±5%		Metal Oxide	0.5W	Welwyn MR5
R40	4.7k ±5%		Metal Oxide	0.5W	Welwyn MR5
R41	5.1k ±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R42	390 ±5%		Metal Oxide	0.5W	Welwyn MR5
R43	33 ±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R44	100 ±10%	Wirewound Potentiometer			Colvern CLR1106/9S
R45	56 ±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R46	10k ±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R47a	10M ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R47b	10M ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R47c	14M ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R48	3.4M ±1%	150ppm	Metal Film	1W	Welwyn 4036G
R49	340k ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R50	57.6k ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R51a	10M ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R51b	10M ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R51c	14M ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R52	3.4M ±1%	150ppm	Metal Film	1W	Welwyn 4036G
R53	340k ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R54	57.6k ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R55a	14M ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R55b	14M ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R56	3M ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R57	316k ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R58	51.1k ±1%	100ppm	Metal Film	1W	Welwyn 4036Z
R59	2M ±20%		Carbon Preset		Beckman 72PM

Resistors continued

Ref	Component				Rating	Man'ftr. & Part No.
R60	1M	±20%	Carbon Preset			Beckman 72PM
R61	50k	±20%	Carbon Preset			Beckman 72PM
R62	10k	±20%	Carbon Preset			Beckman 72PM
R63	10k	±5%		Metal Oxide	0.5W	Welwyn MR5
R64	150k	±5%		Metal Oxide	0.5W	Welwyn MR5
R65	1k	±5%		Metal Oxide	0.5W	Welwyn MR5
R66	3.3k	±5%		Metal Oxide	0.5W	Welwyn MR5
R67	10k	±5%		Metal Oxide	0.5W	Welwyn MR5
R68	500	±10%	Wirewound Potentiometer			Colvern CLR1106/9
R69	AIC			Metal Oxide	0.5W	Welwyn MR5
R70	160	±5%		Metal Oxide	0.5W	Welwyn MR5
R71	5.6k	±5%		Metal Oxide	0.5W	Welwyn MR5
R72	470	±5%		Metal Oxide	0.5W	Welwyn MR5
R73	2.2k	±5%		Metal Oxide	0.5W	Welwyn MR5
R74	56k	±5%		Metal Oxide	0.5W	Welwyn MR5
R75	10k	±5%		Metal Oxide	0.5W	Welwyn MR5
R76	220k	±5%		Metal Oxide	0.5W	Welwyn MR5
R77	22k	±5%		Metal Oxide	0.5W	Welwyn MR5
R78	1k	±5%		Metal Oxide	0.5W	Welwyn MR5
R79	82k	±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R80	68k	±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R81	3.3k	±5%		Metal Oxide	0.5W	Welwyn MR5
R82	10k	±5%		Metal Oxide	0.5W	Welwyn MR5
R83	2.5k	±10%	Wirewound Potentiometer			Colvern CLR1106/9S
R84	15k	±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R85	64.9k	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R86	20.5k	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R87	6.49k	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R88	2.05k	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R89	105	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R90	91	±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C

Resistors continued

Ref	Component			Rating	Man'ftr. & Part No.
R91	82.5 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R92	73.2 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R93	64.9 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R94	57.6 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R95	51.1 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R96	46.4 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R97	41.2 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R98	36.5 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R99	300 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R100	10 ±5%		Carbon Film	0.5W	Welwyn MR5
R101	1.5k ±5%		Carbon Film	0.5W	Welwyn MR5
R102	953 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R103	143 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R104	100k ±5%		Metal Oxide	0.5W	Welwyn MR5
R105	1k ±5%		Metal Oxide	0.5W	Welwyn MR5
R106	1k ±20%		Carbon Preset		Erie 81/P
R107	820 ±5%		Metal Oxide	0.5W	Welwyn MR5
R108	1.6k ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R109	402 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R110	2.2k ±5%		Metal Oxide	0.5W	Welwyn MR5
R111	6.8k ±5%		Metal Oxide	0.5W	Welwyn MR5
R112	10 ±5%		Metal Oxide	0.5W	Welwyn MR5
R113	10 ±5%		Metal Oxide	0.5W	Welwyn MR5
R114	75 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R115	140 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R116	604 ±0.5%	50ppm	Metal Film	0.125W	Welwyn 4033C
R117	68k ±5%		Metal Oxide	0.5W	Welwyn MR5
R118	68k ±5%		Metal Oxide	0.5W	Welwyn MR5
R119	3.9k ±5%		Metal Oxide	0.5W	Welwyn MR5
R120	3.9k ±5%		Metal Oxide	0.5W	Welwyn MR5
R121	18.2k ±1%	50ppm	Metal Film	0.125W	Welwyn 4033C
R121a	AIC		Metal Oxide		Welwyn MR5

Resistors continued

Ref	Component			Rating	Man'ftr. & Part No.
R122	6.8M ±1%	100ppm	Carbon Film	0.25W	Welwyn 4034Z
R122a	2.2M±1%	100ppm	Carbon Film	0.25W	Welwyn 4034Z
R123	100 ±5%		Metal Oxide	0.5W	Welwyn MR5
R124	47 ±5%		Metal Oxide	0.5W	Welwyn MR5
R125	22k ±5%		Metal Oxide	0.5W	Welwyn MR5
R126	82k ±5%		Metal Oxide	0.5W	Welwyn MR5
R127	47 ±5%		Metal Oxide	0.5W	Welwyn MR5
R128	2.7k ±5%		Metal Oxide	0.5W	Welwyn MR5
R129	390 ±5%		Metal Oxide	0.5W	Welwyn MR5
R130	2.7k ±5%		Metal Oxide	0.5W	Welwyn MR5
R131	6.8k ±5%		Metal Oxide	0.5W	Welwyn MR5
R132	270k ±2%		Metal Oxide	0.5W	Welwyn MR5
R133	AIC ±5%		Metal Oxide	0.5W	Welwyn MR5
R134	2.2k ±5%		Metal Oxide	0.5W	Welwyn MR5
R135	15k ± 1%	50ppm	Metal Film	0.125W	Welwyn 4033C

Capacitors

C1	1	±10%	Polyester	400V	Wima Tropyfoil M
C2	1	±10%	Polyester	400V	Wima Tropyfoil M
C3	22p	±10%	Polystyrene	125V	DRB 8018B
C4	2-23p		Trimmer		Oxley TU/24/PC1
C5	22	-10+50%	Electrolytic	40V	Mullard 108-17229
C6	22n	±20%	Polyester	400V	S.T.C. P.M.T. 2R0 .022-M400
C7	470	-10+50%	Electrolytic	16V	Mullard 108 - 15471
C8	68	±20%	Tantalum	25V	ITT TAA 68m 25D
C9	33n	±20%	Polyester	250V	S.T.C. P.M.T. 2R0 .033-M250
C10	47n		Ceramic	30V	Erie 811T/30V/.047
C11	47n		Ceramic	30V	Erie 811T/30V/.047
C12	1n	±10%	Polystyrene	125V	DRB 8018B
C13	47p	±10%	Polystyrene	125V	DRB 8018B
C14	470	-10+50%	Electrolytic	16V	Mullard 108 - 15471
C15	47	-20+50%	Electrolytic	25V	Mullard 108-16479

Capacitors continued

C17	100	-10+50%	Electrolytic	25V	Mullard 108-16101
C18a, b, c	518p swing 3-gang Variable				Jackson EH3/G25
C19	27p	±10%	Polystyrene	125V	DRB 8018B
C20	22p	±10%	Polystyrene	125V	DRB 8018B
C22	2-29p		Trimmer		Oxley TU/30/T
C23	2-29p		Trimmer		Oxley TU/30/T
C24	2-29p		Trimmer		Oxley TU/30/T
C25	2-29p		Trimmer		Oxley TU/30/T
C26	47	-10+50%	Electrolytic	25V	Mullard 108-16479
C27	10	-10+50%	Electrolytic	63V	Mullard 108-18109
C28	100p	±10%	Polystyrene	125V	DRB 8018B
C29	220n	±20%	Polyester	160V	Waycom Tropyfoil M
C30	100	-10+50%	Electrolytic	25V	Mullard 108-16101
C31	100	-10+50%	Electrolytic	63V	Mullard 108-18101
C32	10	-10+50%	Electrolytic	63V	Mullard 108-18109
C33	220	-10+50%	Electrolytic	16V	Mullard 108-15221
C34	10n	±20%	Polyester	400V	Waycom Tropyfoil M
C35	470	-10+50%	Electrolytic	16V	Mullard 108-15471
C36	47	-10+50%	Electrolytic	25V	Mullard 108-16479
C37	1000	-10+50%	Electrolytic	16V	Mullard 108-15102
C38	47n		Ceramic	30V	Erie 811T/30v/.047
C39	2-29p		Air Spaced Trimmer		Oxley A7/30
C40	130p	±10%	Polystyrene	125V	DRB 8018B
C40a	AIC	±10%	Polystyrene	125V	DRB 8018B
C41	3.3n	±10%	Polystyrene	125V	DRB 8018B
C42	10	±20%	Tantalum	20V	ITT TAA 10M 20B
C43	100	-10+50%	Electrolytic	63V	Mullard 108 - 18101
C44	470p	±10%	Polystyrene		DRB 8018B
C45	470p	±10%	Polystyrene		DRB 8018B
C46	4.7	-10+50%	Electrolytic	63V	Mullard 108-18478
C47	22p	±10%	Polystyrene	125V	DRB 8018B
C48	15p	±10%	Polystyrene	125V	DRB 8018B
C49	27p	±10%	Polystyrene	125V	DRB 8018B

Capacitors continued

C50	39p	±10%	Polystyrene	125V	DRB 8018B
C51	2.2n	±10%	Polystyrene	125V	DRB 8018B
C52	1.5-12.5p		Air Spaced Trimmer		Oxley A7/12.5
C53	5p	±1p	Polystyrene	400V	Suflex H.S.
C54	6.8n	±5%	Polystyrene	500V	DRB6021
C55	100	±10%	Polystyrene	125V	DRB8018B
C56	330p	±10%	Polystyrene	125V	DRB 8018B
C58	150p	±10%	Polystyrene	125V	DRB 8018B
C60	AIC	±10%	Polystyrene	125V	DRB 8018B
C61	0.47	±20%	Polyester	160V	Waycom Tropyfoil M

Semiconductors

Ref		Component	Man'ftr. & Part No.	Service Equiv.
VT1*	n.p.n.	Bipolar Transistor	Ferranti 2N930S	
VT2•	n.p.n.	Bipolar Transistor	Ferranti 2N930S	
VT3•	n.p.n.	Bipolar Transistor	Ferranti 2N930S	
VT4*	n.p.n.	Bipolar Transistor	Ferranti 2N930S	
VT5	n.p.n.	Bipolar Transistor	Mullard BC108	CV10541
VT6	n.p.n.	Bipolar Transistor	Mullard BC108	CV10541
VT7	p.n.p.	Bipolar Transistor	Mullard BCY72	CV10235
VT8	n.p.n.	Bipolar Transistor	Mullard BC108	CV10541
VT9	n.p.n.	Bipolar Transistor	Mullard BC109	CV10806
VT10	p.n.p.	Bipolar Transistor	Mullard BCY72	CV10235
VT11	n channel Junction F.E.T.		Mullard BFW11	
VT12	p.n.p.	Bipolar Transistor	Mullard BCY70	CV10990
VT13	n.p.n.	Bipolar Transistor	Mullard BFY90	CV10533
VT14	p.n.p.	Bipolar Transistor	Mullard BCY72	CV10235
VT15	n.p.n.	Bipolar Transistor	Mullard BC107A	
VT16	p.n.p.	Bipolar Transistor	Mullard BCY72	CV10235
VT17	n.p.n.	Bipolar Transistor	Mullard BC108	CV10541
VT18	n.p.n.	Bipolar Transistor	Mullard BC109	CV10806
VT19	p.n.p.	Bipolar Transistor	Mullard BCY72	CV10235
VT20	p.n.p.	Bipolar Transistor	Mullard BCY72	CV10235
VT21	n.p.n.	Bipolar Transistor	Mullard BC107	CV9780

Semiconductors continued

Ref	Component	Man'ftr. & Part No.	Service Equiv.
VT22	n.p.n. Bipolar Transistor	Mullard BC108	CV10541
VT23	n.p.n. Bipolar Transistor	Mullard BC107	CV9780
VT24	p.n.p. Bipolar Transistor	Mullard BCY70	CV10990
VT25	n.p.n. Bipolar Transistor	Mullard BC107A	
VT26	n.p.n. Bipolar Transistor	Mullard BC107A	
IC1	S.I.C. Operational Amplifier	Texas 702HC	
*VT1 and VT4	Matched pair $\left.\right\}$	$\frac{h_{FE}\text{min}}{h_{FE}\text{max}}$ = 0.8 min @ 2mA	
•VT2 and VT3	Matched pair $\left.\right\}$		
D1	Silicon Diode	Mullard BAX13	CV9637
D2	Silicon Diode	Mullard BAX13	CV9637
D3	Silicon Diode	Mullard BAX13	CV9637
D4	Silicon Diode	Mullard BAX13	CV9637
D5	Silicon Diode	Mullard BAX13	CV9637
D6	Diode	Hewlett Packard	5082-2800
D7	Diode	Hewlett Packard	5082-2800
D8	Silicon Diode	Texas 1S920	CV9416
D9	Silicon Diode	Mullard BAX13	CV9637
D10	Silicon Diode	Mullard BAX13	CV9637
D11	Silicon Diode	Texas 1S 920	CV9416
D12	Silicon Diode	Texas 1S 920	CV9416
D13	Silicon Diode	Texas 1S 920	CV9416
D14	Silicon Diode	Texas 1S920	CV9416

Miscellaneous

M1	Meter	Sangamo Weston S829	D 18116
T1	D.C. - D.C. Convertor Tran'fr.	W.K. AH/A/21728	
JK1	3 Terminal Jack Socket	Rendar R328-200-00	
JK2	3 Terminal Jack Socket	Rendar R328-270-00	
JK3	3 Terminal Jack Socket	Rendar R328-270-00	
SA	Switch, rotary	W.K. AH/A/21707	

Miscellaneous continued

SB	Switch, rotary	W.K. AH/A/21704
SC	Switch, rotary	W.K. AH/A/21706
SD	Switch, rotary	W.K. AH/A/21708
SE	Switch, rotary	W.K. AH/A/21701
SF	Switch, rotary	W.K. AH/A/21702
SG	Switch, lever	NSF MLA3 450379
SH	Switch, rotary	W.K. AH/B/21705
SJ	Switch, push button	Rendar PBS-1-B-R52201

MP MASTER
MA24491

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Fragile. Handle with care

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